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**Unit 4, Part 2 Notes: Photosynthesis**

Ms. Ottolini, PreAP Biology

**Overview of Photosynthesis:**

Autotrophs are organisms that can make their own glucose. Some organisms use sunlight as an energy source to fuel the creation (synthesis) of glucose. These organisms are called photoautotrophs and the process they use to create glucose is called photosynthesis. Organisms that use photosynthesis include plants, algae, and some bacteria.

During photosynthesis, organisms break apart the bonds holding together carbon dioxide (CO2) and water (H2O) molecules. They then rearrange the atoms from carbon dioxide and water to form glucose (C6H12O6). They energy used to fuel this process is the energy from sunlight. The overall equation for photosynthesis is given below, with the reactants (starting molecules) on the left side of the arrow and the products (ending molecules) on the right side of the arrow.

***Equation with Chemical Symbols:***

CO2 + H2O + light 🡪 C6H12O6 + O2

***Equation with Words:***

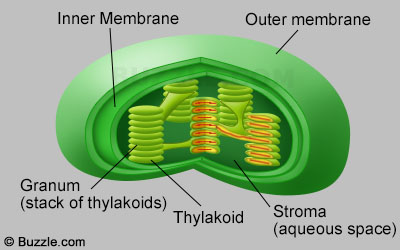
carbon dioxide + water + light 🡪 glucose + oxygen

**Where does Photosynthesis Occur?**

Photosynthesis occurs in the chloroplasts of plant cells. Scientists believe that chloroplasts became part of eukaryotic cells by the same process as mitochondria. This process is called endosymbiosis and involved a larger prokaryotic cell swallowing a smaller prokaryotic cell that was particularly good at performing photosynthesis. This smaller cell provided a source of glucose for the cell and in-turn received a nice place to live.

Evidence to suggest that chloroplasts were once free-living prokaryotic cells includes the fact that they have their own DNA and ribosomes. They also have a double membrane—one from their former life as free-living cells and one that they received when the large cell wrapped its membrane around them during the “swallowing” process.

Chloroplasts have an outer and inner membrane. The space between the membranes is called the intermembrane space, and the inside of the chloroplast (inside both membranes) is called the stroma. The stroma is filled with a fluid similar to the cytoplasm of the cell. Within the stroma, there are stacks of membrane disks. Each disk is called a thylakoid, and each stack is called a granum (plural: grana). The first step of photosynthesis—the light-dependent reactions (aka the light reactions)—occurs in the membranes of the thylakoid disks. The second step of photosynthesis—the Calvin cycle (aka the light-independent reactions or dark reactions)—occurs in the stroma.



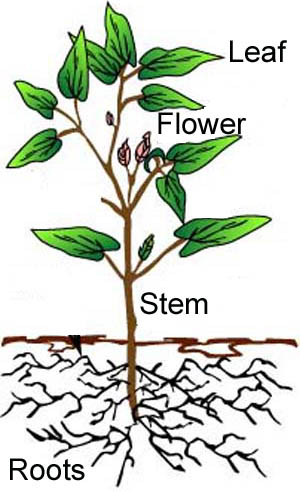
**What are the Steps of Photosynthesis?**

The first step of photosynthesis is called the light reactions. During the light reactions, a green pigment called chlorophyll located in the thylakoid membrane absorbs sunlight. The energy from sunlight is used to create a small amount of ATP and to “excite” / energize some electrons from the chlorophyll molecule. These electrons are given to NADPH (a piggy bank / electron carrier similar to NADH from cellular respiration), which carries them to the Calvin cycle in the stroma. The overall goal of the light reactions is to create ATP and NADPH and send them to the stroma, where their energy can be used to fuel the Calvin cycle.

So that the light reactions can continue, the electrons from chlorophyll that were “excited” and given to NADPH must be replaced. Water, one of the reactants (i.e. starting molecules) is split (using energy from sunlight) into oxygen gas (O2), H+, and electrons. These electrons are then “donated” to chlorophyll.

The second step of photosynthesis is called the Calvin cycle. During the Calvin cycle, energy from ATP and the electrons carried by NADPH is used to create glucose from the carbon (C), hydrogen (H), and Oxygen (O) found in carbon dioxide and water. The Calvin cycle does not require sunlight like the light reactions. Therefore, it is often called the dark reactions or light-independent reactions. However, the Calvin cycle relies on the ATP and NADPH created by the light reactions, so though it does not require light directly, it would eventually stop if light were not present to fuel the light reactions.

**What Factors Affect the Rate of Photosynthesis?**

If there is more light reaching the thylakoid membranes, the rate (speed) of photosynthesis and the amount of glucose will increase. In addition to light intensity, increasing the amount of water and carbon dioxide available to the plant cell will increase the rate of photosynthesis as well. Photosynthesis also occurs faster at higher temperatures.

**How do Plants Acquire the Reactants and Release the Products of Photosynthesis?**

Plants take in water through their roots and transport it from their roots to their leaves (where most photosynthesis occurs) though a tube-like tissue in their stems called the xylem. Water moves up the tube against gravity using capillary action (think back to our biochemistry unit!). Plants take in and release carbon dioxide through holes on the bottom of their leaves called stomata.



*stomata on the underside of a leaf*

**Questions to Accompany the Notes**

***Directions:*** *Answer each question below thoroughly and accurately. Use complete sentences.*

1. What are the reactants and products of photosynthesis?
2. Where do the two steps of photosynthesis (i.e. the light reaction and the Calvin cycle) occur in the chloroplast?
3. What is the overall goal of the light reactions?
4. Describe the role of NADPH in photosynthesis?
5. What is the overall goal of the Calvin cycle?
6. Why would the Calvin cycle stop if there was no sunlight?
7. List the factors that could cause a DECREASE in the rate of photosynthesis / amount of glucose created.
8. How do plants transport water from their roots to their leaves?
9. Why does water enter the root cells by osmosis? *(Note: This question relates more to cell transport than photosynthesis. Describe why water would move from the soil to the inside of the root cells based on its concentration in the soil and the root cells.)*
10. How do plants take in carbon dioxide and release oxygen?
11. Why do leaf cells have more chloroplasts than cells in the rest of the plant?
12. Why do rain forest plants have extra large leaves? *(Note: Plants in the rainforest tend to receive very little sunlight due to the dense canopy trees.)*
13. Look at the equations for cellular respiration and photosynthesis. Why do scientists argue that cellular respiration and photosynthesis work together like a cycle?